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hanced lines in the early F stars are normally so prominent that it is not surprising that the method begins to break down at this point.

To illustrate the use of the formulae and curves we may select as illustrations a few stars of different spectral types and magnitudes. These are collected in Table II. The classification is from Mount Wilson determinations.

TABLE II

STAR	MAG.	TYPE	Δ			M			PARALLAX		
			(a)	(b)	(c)	(a)	(b)	(c)	Mean	Comp.	Obs.
Pi 10 ^h 96....	7.6	F5	-0.7	+0.7	+3.0	+6.5	4.7	5.8	5.7	+0".04	+0".04
Sun.....		G0	-0.5	+0.5	+3.0	+5.6	4.3	5.8	5.2		
Lal. 38287..	7.2	G5	-1.8	+1.5	+3.5	+7.4	+6.3	+6.2	7.3	+0.10	+0.09
α Arietis...	2.2	K0	+2.5	-2.4	+0.2	+1.0	1.3	+0.2	0.8	+0.05	+0.09
α Tauri....	1.1	K5	+3.0	-2.0	+0.5	-0.4	+1.9	+0.5	0.7	+0.08	+0.07
61 ² Cygni..	6.3	K8	-1.8	+5.8	+7.7	+8.2	9.3	8.9	8.8	+0.32	+0.31
Groom. 34..	8.2	Ma	-2.2	+6.8	+9.2	+10.2	10.5	10.4	10.4	+0.28	+0.28

The parallaxes are computed from the absolute magnitudes by the formula, to which reference has already been made,

$$5 \log \pi = M - m - 5.$$

The results are given in the next to the last column of the table, and the measured parallaxes in the final column.

INVESTIGATIONS IN STELLAR SPECTROSCOPY. III. APPLICATION OF A SPECTROSCOPIC METHOD OF DETERMINING STELLAR DISTANCES TO STARS OF MEASURED PARALLAX

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A definite test of the value of this method of deriving stellar parallaxes can be made only through a comparison with all available data on measured parallaxes. Since the evidence depends directly on individual values it is necessary for this purpose to present tables of a somewhat extended character.

It is evident that in the case of the stars whose absolute magnitudes, as computed from the measured parallaxes have been used in the derivation of the relationship between line intensity and absolute magnitude, the mean values of the magnitude will necessarily be identical with those derived from the formulae. The agreement of the measured and the

computed parallaxes of the individual stars, however, serves as important evidence bearing on the validity of the method.

In Tables I and II are collected all of the stars with measured parallaxes equal to or exceeding $+0''.05$ for which we have spectral observations. Table I contains the stars used in the derivation of the curves, but in Table II the values are entirely independent, none of these stars having been used previously. This table, accordingly, serves as a most exacting test of the value of this means of computing parallaxes.

TABLE I

STAR	MAG.	TYPE	M		PARALLAX		Mean	Measured parallax	Authority
			A	B	A	B			
F8-G7									
μ Cassiop.....	5.2	G3	+4.7	+5.2	+0 ^u .08	+0 ^u .10	+0 ^u .09	+0 ^u .11	K.
ϵ Persei.....	4.2	G1	3.3	3.3	0.07	0.07	0.07	0.11	K.
Lal. 6888.....	8.4	G7	7.5	7.5	0.07	0.07	0.07	0.06	K.
α Aurigae.....	0.2	G0	0.5	0.6	0.11	0.12	0.12	0.09	Y.
λ Aurigae.....	4.8	G1	4.8	5.0	0.10	0.11	0.11	0.11	K.
Lal. 11196.....	6.5	G1	5.0	6.6	0.05	0.10	0.08	0.09	K.
Lal. 15565.....	6.9	G4	6.3	6.4	0.08	0.08	0.08	0.09	K.
Pi 7 ^h 321.....	7.0	G2	7.0	6.1	0.10	0.07	0.08	0.05	K.
Groom. 1596...	8.2	G6	5.1	5.4	0.02	0.03	0.03	0.07	Y.
20 Leo Min....	5.6	G4	4.7	5.6	0.07	0.10	0.08	0.07	K.
Groom. 1830...	6.5	G6	5.9	5.9	0.08	0.08	0.08	0.10	K.
Groom. 1855...	7.4	G7	6.0	5.4	0.05	0.04	0.05	0.06	K.
Lal. 22908.....	7.5	G3	5.8	5.8	0.06	0.06	0.06	0.09	Y.
Lal. 30694.....	6.8	G6	5.3	5.9	0.05	0.07	0.06	0.07	K.
Lal. 31132.....	6.7	G4	6.4	7.0	0.09	0.11	0.10	0.14	Y.
72 w Herculis..	5.4	G1	6.3	5.9	0.15	0.13	0.14	0.12	K.
31 b Aquilae...	5.2	G7	5.3	4.8	0.10	0.08	0.09	0.07	K.
Lal. 37120.....	6.6	F9	4.7	5.3	0.04	0.05	0.05	0.06	Y.
Lal. 38287.....	7.2	G5	7.3	6.7	0.10	0.08	0.09	0.09	Y.
85 Pegasi.....	5.9	G1	5.8	6.1	0.10	0.11	0.10	0.09	S. & M.
G8-K4									
54 Piscium	6.1	K0	+7.0	+6.4	+0 ^u .15	+0 ^u .11	+0.13	+0 ^u .14	Y.
Mayer 20.....	5.8	K3	7.2	7.1	0.19	0.18	0.18	0.16	K.
Pi 1 ^h 159.....	5.7	K0	6.2	4.9	0.13	0.07	0.10	0.10	K.
α Arietis.....	2.2	K0	0.8	-0.1	0.05	0.03	0.04	0.05	K.
W.B. 3 ^h 113....	7.8	K0	6.5	6.3	0.06	0.05	0.06	0.08	Y.
Pi 5 ^h 146.....	6.4	G9	6.2	5.4	0.06	0.06	0.08	0.12	K.
Lal. 13427.....	8.2	K3	7.0	7.2	0.06	0.06	0.06	0.05	K.
β Gemin.....	1.2	G8	-0.1	1.0	0.05	0.09	0.07	0.06	Y.
Lal. 16304.....	6.0	G8	7.4	6.9	0.19	0.15	0.17	0.11	Y., F.
55 ρ Cancri....	6.0	K1	5.2	5.6	0.07	0.08	0.08	0.08	K.
α Boötis.....	0.2	G9	0.1	0.7	0.10	0.13	0.11	0.08	K.
W.B. 15 ^h 720...	6.8	K3	5.9	5.0	0.07	0.04	0.06	0.05	R.
Lal. 30024.....	7.0	K3	7.5	7.3	0.13	0.11	0.12	0.09	Y.
Fed. 2895.....	6.3	G9	6.9	5.9	0.13	0.08	0.10	0.05	Y.
Pi 20 ^h 23.....	7.3	K2	7.3	7.1	0.10	0.09	0.09	0.08	Y.

TABLE I (Continued)

STAR	MAG.	TYPE	M		PARALLAX		Mean	Measured parallax	Authority
			A	B	A	B			
K5-K9									
Lal. 1799.....	8.0	K5	7.5	6.4	0.08	0.05	0.06	0.06	Y.
Lal. 1964.....	8.6	K5	8.0	8.2	0.08	0.08	0.08	0.10	Y.
Pi 2 ^h 123.....	5.9	K6	6.7	5.8	0.14	0.10	0.12	0.14	K.
Groom. 745....	8.3	K7	8.7	8.2	0.12	0.10	0.11	0.08	K.
α Tauri.....	1.1	K4	0.7	1.9	0.08	0.14	0.11	0.07	K.
Lal. 18115 Pr...	7.9	K8	9.0	8.7	0.17	0.14	0.16	0.16	K.
Lal. 18115 Fol..	7.9	K8	9.0	9.6	0.17	0.22	0.19	0.16	K.
Lal. 19022.....	8.2	K6	6.9	7.3	0.05	0.07	0.06	0.06	K.
A. Oe. 10603...	6.8	K8	7.9	8.3	0.17	0.20	0.18	0.18	K.
O ϵ 298.....	7.9	K6	6.8	6.9	0.06	0.06	0.06	0.05	R.
Brad. 2179....	6.7	K4	8.2	7.8	0.20	0.17	0.18	0.15	F.
W.B. 17 ^h 322...	7.8	K7	8.6	8.9	0.14	0.17	0.15	0.12	K.
70 Ophiuchi Ft.	6.0	K7	7.8	7.6	0.23	0.21	0.22	0.17	K.
Lal. 40844.....	9.0	K5	8.8	7.9	0.09	0.06	0.08	0.17	Y.
61 ¹ Cygni.....	5.6	K8	8.5	7.2	0.38	0.21	0.30	0.31	K.
61 ² Cygni.....	6.3	K8	8.8	9.0	0.32	0.35	0.34	0.31	K.
Brad. 3077.....	5.6	K7	6.7	6.8	0.17	0.17	0.17	0.16	K.
Ma-Mb									
Groom. 34.....	8.2	Ma	10.4	10.3	0.28	0.26	0.27	0.28	K.
Lal. 21185.....	7.6	Ma	10.6	10.6	0.40	0.40	0.40	0.40	K.
Lal. 21258.....	8.9	Ma	10.5	10.3	0.21	0.19	0.20	0.20	K.
Lal. 25372.....	8.7	Ma	10.0	9.6	0.18	0.15	0.16	0.18	K.
Kruger 60.....	9.2	Ma	10.3	10.0	0.17	0.15	0.16	0.26	K.
Lal. 46650.....	8.9	Ma	10.3	10.1	0.19	0.17	0.18	0.18	K.

TABLE II

STAR	MAG.	TYPE	M		PARALLAX		Mean	Measured parallax	Authority
			A	B	A	B			
F0-F7									
α Can. Min.. . .	0.5	F3	+3.5	+3.0	+0 ^{''} .40	+0 ^{''} .32	+0 ^{''} .36	+0 ^{''} .32	K.
10 Urs. Maj....	4.1	F6	4.7	3.9	0.13	0.09	0.11	0.09	Y.
39 Leonis.....	5.8	F7	5.1	4.7	0.07	0.06	0.07	0.09	Y.
3 Cygni.....	6.2	F3	5.9	5.9	0.07	0.07	0.07	0.07	K.
Groom. 3042...	5.7	F0	5.4	4.8	0.09	0.07	0.08	0.06	Y.
Groom. 3357...	6.6	F7	5.5	5.5	0.06	0.06	0.06	0.08	J.
33 Pegasi.....	6.1	F5	4.7	4.2	0.05	0.04	0.05	0.06	vM.
34 Pegasi.....	5.8	F6	4.6	3.3	0.06	0.03	0.05	0.07	F.
F8-G7									
Brad. 3212.....	6.2	G7	6.7	5.9	0.13	0.09	0.11	0.15	Y.
Lal. 3022.....	7.8	G5	4.0	5.7	0.02	0.04	0.03	0.05	Y.
δ Trianguli....	5.1	F8	5.3	5.0	0.11	0.10	0.10	0.12	K.
Lal. 5490.....	6.7	G2	5.6	4.5	0.06	0.04	0.05	0.06	Y.
10 Tauri.....	4.4	F8	3.4	4.0	0.06	0.08	0.07	0.07	Y.
Groom. 884....	7.1	F9	5.8	6.7	0.06	0.08	0.07	0.09	K.
Lal. 13849.....	6.5	G7	3.7	3.6	0.03	0.03	0.03	0.11	Y.
Pi 6 ^h 305.....	6.0	G0	5.4	4.8	0.08	0.06	0.07	0.07	K.
Groom. 1281...	5.6	F9	5.4	4.8	0.09	0.07	0.08	0.07	J.
Lal. 14146.....	7.3	F9	6.5	5.6	0.07	0.05	0.06	0.08	Y.
Brad. 1433.....	5.9	F7	4.5	4.2	0.05	0.05	0.05	0.10	J., M.
Groom. 1646...	6.5	G1	6.6	5.8	0.10	0.07	0.08	0.08	K.
Lal. 22585.....	6.4	G7	3.7	3.7	0.03	0.03	0.03	0.12	Y.

TABLE II (Continued)

STAR	MAG.	TYPE	M		PARALLAX		Mean	Measured parallax	Authority
			A	B	A	B			
Lal. 25012.....	7.5	G7	7.7	7.6	0.11	0.10	0.10	0.05	Y.
Lal. 26289.....	6.3	G2	4.8	5.4	0.05	0.07	0.06	0.11	Y., J.
χ Herculis.....	4.6	F8	4.8	3.9	0.11	0.07	0.09	0.10	Y.
Groom. 2305...	6.8	G5	6.6	7.6	0.09	0.14	0.11	0.07	Y.
Lal. 30699.....	7.8	G6	5.4	4.6	0.03	0.02	0.03	0.05	Y.
26 Draconis....	5.3	G0	5.1	5.1	0.09	0.09	0.09	0.09	Y.
16 Cygni Pr....	6.3	G1	6.0	5.0	0.09	0.05	0.07	0.05	S. & M.
16 Cygni Fol...	6.4	G3	4.2	3.7	0.04	0.03	0.04	0.04	S. & M.
Lal. 38380.....	5.7	G7	4.5	3.3	0.06	0.03	0.05	0.06	Y., F.
15 Sagittae.....	5.9	G1	5.2	4.6	0.07	0.05	0.06	0.10	K.
Groom. 3150...	6.1	G0	6.9	6.4	0.14	0.11	0.12	0.12	Y.
ρ Cygni.....	4.2	G5	3.6	2.8	0.08	0.05	0.06	0.05	Y.
Fed. 4371.....	7.5	G1	7.5	6.8	0.10	0.07	0.08	0.06	Y.
107 Piscium....	5.3	K2	5.8	5.9	0.13	0.13	0.13	0.13	Y.
W. B. 2 ^h 927....	8.2	G9	5.5	5.2	0.03	0.03	0.03	0.10	Y.
ϵ Eridani.....	3.8	K3	6.1	5.8	0.29	0.25	0.27	0.31	Y.
δ Eridani.....	3.7	G9	2.6	1.1	0.06	0.03	0.05	0.19	Y.
Lal. 10797.....	7.3	K0	5.5	5.0	0.04	0.03	0.04	0.08	Y.
Lal. 15547.....	8.6	K1	5.5	4.7	0.02	0.02	0.02	0.09	Y.

G8-K4

83 Leonis B r...	6.5	G8	+5.8	+4.3	+0 ^u .07	+0 ^u .04	+0 ^u .06	+0 ^u .06	R.
Lal. 26196.....	7.6	K2	7.6	6.2	0.10	0.05	0.08	0.14	Y.
Lal. 27298.....	7.9	G9	6.6	7.4	0.05	0.08	0.06	0.06	K.
Lal. 27744.....	6.7	G8	7.2	5.6	0.13	0.06	0.10	0.09	F., Lee
Lal. 33439.....	6.7	K3	6.7	6.4	0.10	0.09	0.09	0.05	Y.
Lal. 38383.....	7.2	K1	7.3	7.8	0.10	0.13	0.12	0.11	Y.
η Cephei.....	3.6	K1	1.8	2.0	0.04	0.05	0.05	0.08	Y., S.
A. Oe. 25685...	7.5	K0	6.5	5.4	0.06	0.04	0.05	0.08	Y.
γ Cephei.....	3.4	K2	3.5	2.2	0.10	0.06	0.08	0.07	S. & M.

K5-K9

Lal. 47231.....	8.6	K6	8.8	9.3	0.11	0.14	0.12	0.12	Y., S.
Lal. 1198.....	8.1	K7	6.3	5.4	0.04	0.03	0.04	0.08	Y.
Lal. 6320.....	7.9	K8	8.0	7.4	0.10	0.08	0.09	0.07	Y.
W.B. 4 ^h 1189...	6.5	K7	7.1	6.4	0.13	0.10	0.12	0.11	Y.
Lal. 10299.....	8.5	K7	8.2	8.8	0.09	0.11	0.10	0.10	Y.
Lal. 13284.....	6.9	K5	6.6	8.3	0.09	0.19	0.14	0.12	Y.
83 Leonis Ft..	7.6	K7	6.3	6.5	0.05	0.06	0.06	0.06	R.
Pi 14 ^b 212 Br...	5.8	K6	7.6	6.6	0.23	0.15	0.19	0.17	K.
Lal. 31055.....	7.9	K6	7.8	7.3	0.10	0.08	0.09	0.07	Y., F.
Lal. 34986.....	8.1	K6	7.7	7.3	0.08	0.07	0.08	0.08	Y.
B. D. +7 ^h 3967.	9.3	K5	8.7	7.6	0.08	0.05	0.06	0.04	Sch.
Lal. 39866.....	8.4	K3	8.4	6.8	0.10	0.05	0.08	0.06	Y.
Lal. 45028.....	7.8	K5	6.3	5.7	0.05	0.04	0.05	0.05	Y.

Ma

Fed. 1384 ¹	9.2	Ma	9.9	10.4	0.14	0.17	0.15	0.10	F.
W. B. 16 ^h 906..	8.8	Ma	10.1	10.0	0.18	0.17	0.18	0.22	Y.
A. Oe. 17415...	9.1	Mb	10.6	10.8	0.20	0.22	0.21	0.27	K.
Pos. Med. 2164 ¹	8.9	Mb	10.5	10.6	0.21	0.22	0.22	0.29	K.

The columns in the tables designated by A and B refer to the determinations by Adams and Miss Burwell. The final values are the means for the two observers. The measured parallaxes are taken from a variety of sources. Y. indicates Yale determinations; K., the values compiled by Kapteyn in *Groningen Publication* No. 24; Sch., the results of Schlesinger; R., those of Russell; vM., of van Maanen; S., of Slocum; M., of Mitchell; J., of Jost; and F., those of Flint. Where relative parallaxes are given the values have been reduced to absolute measure by making suitable corrections for the parallaxes of the comparison stars. The tables are arranged according to spectral type.

The comparison of the computed and the measured parallaxes shows an excellent degree of accordance for most of the stars. There are, however, occasional large discrepancies. Of these the most serious is in the case of δ *Eridani*. The spectrum observations give a much smaller parallax than is found by the Yale observers. A striking case of agreement, on the other hand, is that of ϵ *Eridani*; this parallax was computed before it was known that a measured value was available. A star which should prove of exceptional interest is Boss 6129. From spectrum observations we have obtained a parallax of $+0''.23$; no measured value has been published but the star is on the observing programme at several observatories.

The average deviation, taken without regard to sign, between the observed and the computed values of the parallaxes in Tables I and II is $0''.024$: it is $0''.026$ for the stars of Table II alone. There seems to be no marked systematic difference between the observed and the computed parallaxes; the former average somewhat larger, but this is due mainly to a few large discrepancies.

There are 25 stars with measured negative parallaxes for which we have made spectrum determinations. The largest value for any one of these stars as computed from the line intensities is $+0''.08$; the average value for all is $+0''.03$. The spectrum method, of course, gives no negative parallaxes.

It seems reasonable to conclude from these results that the method of computing absolute magnitudes and parallaxes from the variation of the intensities of lines in stellar spectra is capable of yielding results of a very considerable degree of accuracy. Especially in the K and M type stars of low luminosity, the line variations are so great that such stars may be recognized from a mere inspection of the spectrum. Stars, for example, like 61 Cygni, Groom. 34, and Krüger 60 bear very evident marks of their intrinsic faintness in the remarkable intensity of the low temperature calcium lines in their spectra. At first thought it might

appear that a relationship between certain spectral characteristics and the distances of stars could hardly be credible, since it would appear like a correlation between two utterly unrelated subjects except in so far as the scattering of light in space might connect them. In fact, of course, it is not the distances but the absolute magnitudes of stars which have an influence on the character of the spectrum lines and such an effect, far from being improbable, is rather to be expected than not. The derivation of the distances is merely a by-product resulting from the combination of real, or absolute, with apparent magnitudes.

An important gain in the value of this method of determining stellar magnitudes and distances should result from an increase in the number of measured parallaxes of bright stars of small proper motion. Such stars will on the average prove to be very luminous, and, as already stated, the portion of the curves connecting line intensity with absolute magnitude is subject to much more uncertainty in the case of the high luminosity stars than in any of the others. It is probable that after such a revision has been made the method will find its most important application as a means of distinguishing these giant stars in the stellar system.

INVESTIGATIONS IN STELLAR SPECTROSCOPY. IV. SPECTROSCOPIC EVIDENCE FOR THE EXISTENCE OF TWO CLASSES OF M TYPE STARS

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The principal distinguishing feature of the M type of stellar spectrum on the Harvard system of classification is the presence of absorption bands due to titanium oxide. These bands increase in intensity for the successive subdivisions Ma, Mb, and Mc. The star α Orionis, in which they are present in moderate intensity, is selected as a typical Ma star by the Harvard observers. Since these bands may be seen faintly in stars of the K5 type of spectrum it is necessarily largely a matter of judgment whether in any given spectrum they are sufficiently strong to warrant classifying the star as Ma, or whether it should still be retained within the K type.

For types of spectra previous to M the principal basis of classification is the intensity of the hydrogen lines. These reach a maximum in the A type, and grow fainter in the successive types F, G, and K. Of the hydrogen lines in α Orionis, however, Miss Cannon, in the course of